



## 14 Years longitudinal evaluation of clinical information systems acceptance: The HEGP case



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### ABSTRACT

**Context:** Meaningful use and end-user satisfaction are two major components of the success of a clinical information system (CIS). The purpose of this study was to longitudinally measure and analyze the CIS use and satisfaction determinants in a multi-professional group at the Georges Pompidou university hospital (HEGP) in Paris.

**Methods:** From the different evaluation surveys performed at HEGP, three periods were considered corresponding to 4, 8 and over 10 years after the first CIS deployment in 2000, respectively. Six acceptance dimensions were considered: CIS quality (CISQ), facilitating conditions (FC), perceived usefulness (PU), confirmation of expectations (CE), use, and global satisfaction (GS). Relationships between these constructs were tested through multiple regressions analysis and structural equation modeling (SEM).

**Results:** Responses were obtained from 298, 332, and 448 users for the three periods considered. CIS acceptance dimensions progressively and significantly increased over time. Significant differences between professions were observed with an initial low PU among medical staff. In the early deployment phase, GS appeared to be determined by CIS use, CISQ and PU ( $R^2 = .53$  in SEM). In the very late post-adoption phase, GS was strongly determined by CISQ, CE, and PU ( $R^2 = .86$  in SEM) and was no longer associated with CIS use.

**Conclusion:** Acceptance models should be adapted to the phase of deployment of a CIS and integrate end-users' individual characteristics. Progressive reduction over time of the positive relationships between CIS use and satisfaction could possibly be considered as a maturity indicator of CIS deployment. These observations validate the introduction in post-adoption models of a continuance intention dimension.

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### 1. Introduction

In most developed countries, sustained information technology (IT) investments allow the progressive adoption of electronic healthcare records (EHR) and their associated care management and decision support tools [1–4]. For example, in the second 2015

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quarter 23.6% of US hospitals have reached Stage 6 of the Electronic Medical Record Adoption Model of Healthcare Information and Management Systems Society (HIMSS-EMRAM) maturity model [5]. Financial incentives tend to be associated with indicators of IT meaningful use such as the ones considered in the Health Information Technology for Economic and Clinical Health Act of the American Recovery and Reinvestment Act program [6]. The underlying hypothesis is that increased and adequate IT usage will be associated with improved patient care workflows and clinical outcomes, as well as improved productivity and financial returns on investments [7,8]. In such a context, continuous monitoring in any hospital of its clinical information system (CIS) use and end-user satisfaction is critical [9–13]. Satisfied end-users are likely to better use their CIS and enter a win-win strategy with the CIS provider,

e.g., by actively participating in user groups and/or suggesting permanent improvements.

However, the evaluation of acceptance of a deployed system and its determinants is likely to change over time. During the early post-adoption period, not all users may use the CIS functions and not all services and specialties may be covered. The evaluation should be performed as closely as possible to the point of interaction between the CIS and health professional to take into account characteristics of the environment, and CIS usability and workflow integration issues [12,14]. In late post-adoption periods, when major usability and error issues are supposed to be corrected and a meaningful use level reached, CIS use is likely to be mandatory.

Based on available literature and observations in the business area and research studies in social sciences and cognitive psychology, two main categories of IT evaluation models should be considered. The first category (*acceptance models*) aims to predict the behavioral intention of professionals to use a given system (intent to use) and, in a second step, its degree of use (usage) from their degree of satisfaction. The second category tries to measure the degree of satisfaction with a deployed system or try to predict the future behavior of their users to continue to use or better use an existing and running system (*continuance intention models*).

Most *acceptance models* rely on the Theory of Reasoned Action (TRA) or the Theory of Planned Behavior (TPB). Derived from the social psychology setting, TRA was proposed by Fishbein and Ajzen in 1975 [15–17]. It primarily represents the relationship between actual behavior and the behavior intention of users. Behavior intention is determined by both personal beliefs in a solution and the subjective norm associated with the social environment of the targeted user. TPB proposed by Ajzen in 1985 is an extension of the TRA [18]. User behavior is predicted under the hypothesis that all behavioral motivations are under control [19]. Based on these behavioral theories, Davis proposed in 1985 a conceptual model explaining the information system intent to use and its subsequent use [16]. He considered that a user's motivation to use IT is influenced by the system features and capabilities. The conceptual model was improved to become the Technology Acceptance Model (TAM), in which the user motivation is described by three constructs: the attitude toward using a system, the perceived usefulness (PU) and the perceived ease of use (PEOU). The last two constructs directly influence the attitude toward using a system. The PEOU is determined by the system characteristics. The PU is determined by the system characteristics and the PEOU [20,21]. To cope with some TAM limitations, particularly regarding the motivations of the user's PU perception, Venkatesh and Davis proposed a TAM2 model by adding variables considered to affect the PU, such as subjective norm, experience, and output quality [10,22,23]. In 2003, through the study and comparison of many previous models of information system acceptance, Venkatesh et al. proposed a model called the Unified Theory of Acceptance and Use of Technology (UTAUT) [24]. The model explains user intentions to use an information system and their subsequent usage behavior. It considers that the use behavior is determined by behavior intention and facilitating conditions. Behavior intention is determined by performance expectancy, effort expectancy, and social influence. Gender, age, experience, and voluntariness of use are used to analyze the impact of the individual user characteristics constructs on usage intention and behavior.

To distinguish acceptance and continuance behavior, Bhat-tacherjee proposed in 2001 the Expectation Confirmation Model (ECM) of Information System Continuance [25]. The model is based on the expectation confirmation theory (ECT) [26]. The viability of an information system depends on its continued use. The information system continuance intention is determined by the user

satisfaction and the perceived system usefulness. The user satisfaction is determined by the confirmation of expectations (CE) and PU. The model also hypothesizes the existence of a direct influence of CE on PU. Based on the ECM, Palm et al. proposed an Information Technology Post Adoption Model (ITPAM) by adding two system characteristics (CIS compatibility with work and PEOU) from the TAM2, one facilitating condition (CIS support) from the UTAUT, and three end-user characteristics (age, sex and medical profession) [62].

In the TAM2, UTAUT, and ECM models, the PU is considered a determinant of usage (TAM2 and UTAUT) or continuance intention (ECM). In the Information System Success Model (ISSM) proposed by Delone and McLean, the outcome of an information system (IS), under the general term “net benefits”, is considered the final target. In this model, both intent to use and use are related to information system quality, system quality, and service quality. Net benefits are also determined by, and determine use and user satisfaction [27,28].

Acceptance and continuance intention models have been extensively used in the healthcare domain [10,29–36]. However most of these studies have been focused on pre or early post adoption phases (e.g., behavioral intention to use a system or partial functions' deployment) [10,33,34]. Evaluations are also focused on dedicated eHealth applications (e.g., PACS [37], telemedicine [35,38,39], personal digital assistants [40]), specific professional groups (e.g., nurses [14,41–46] or physicians [11,29,47–55]) or clinical information system components (e.g., CPOE [45,47,48,56–58]). They are frequently based on a single validated model such as the TAM model or its derived family (e.g., TAM2, UTAUT) or the Delone and McLean success model [29,55,59,60].

Objective of this paper is to longitudinally evaluate the evolution of the acceptance and use dimension determinants of a fully integrated CIS at the Georges Pompidou University hospital (HEGP) in Paris. Three study periods are considered: early post-adoption (4 years), late post-adoption (8 years) and very late post adoption (>10 years). The results identify the changes observed between the three periods and integrate partial results of the previous surveys performed in the same institution [61–63]. The two main research hypothesis are first, that these determinants are likely to change over time, and second, that no single model from the acceptance literature is sufficient to embrace the complexity of the embedded factors. To our knowledge this paper is the first to measure and analyze in a multi-professional group of end-users these determinants through a 14-year longitudinal evaluation period.

## 2. Materials and methods

### 2.1. The HEGP clinical information system

HEGP is an 820-bed acute care university hospital located in southwest Paris that opened in July 2000 after the merging of three aging facilities. Its fully integrated CIS consists of five major components: (1) an admission, discharge and transfer (ADT) component; (2) an electronic multimedia health record (EHR); (3) a computerized provider order entry component (CPOE); (4) a resource and appointment scheduling system; and (5) a clinical data warehouse (CDW). The first three components are based on the DxCare<sup>®</sup> software suite from Medasys<sup>®</sup>, the fourth on OneCall<sup>®</sup> from McKesson/Maincare<sup>®</sup>, and the fifth on i2b2 [64,65]. Results from ancillary subsystems (e.g., laboratories, imaging, and pharmacy) are automatically integrated into the EHR. All functions of the CIS production environment that correspond to the first four components were operational at the opening of the hospital in July 2000. The CDW integration started in 2009 and made operational to all health professional users in 2011.

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